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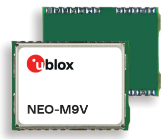
NEO-M9V-20B

u-blox M9 multi-mode dead reckoning module

Professional grade

Data sheet



Abstract

This data sheet describes the u-blox NEO-M9V standard precision with multi-mode dead reckoning (MDR) module. NEO-M9V offers ultra-robust meter-level GNSS positioning performance with concurrent reception of up to four GNSS (GPS, GLONASS, BeiDou, Galileo) together with vehicle speed information and integrated 3D sensors in a 12.2 x 16.0 mm package.

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UBX-21029781 - R01
C1-Public

Document information

Title	NEO-M9V-20B	
Subtitle	u-blox M9 multi-mode dead reckoning module	
Document type	Data sheet	
Document number	UBX-21029781	
Revision and date	R01	05-Jan-2022
Disclosure restriction	C1-Public	

Product status	Corresponding content status	
In development / prototype	Objective specification	Target values. Revised and supplementary data will be published later.
Engineering sample	Advance information	Data based on early testing. Revised and supplementary data will be published later.
Initial production	Early production information	Data from product verification. Revised and supplementary data may be published later.
Mass production / End of life	Production information	Document contains the final product specification.

This document applies to the following products:

Product name	Type number	Firmware version	PCN reference	Product status
NEO-M9V	NEO-M9V-20B-00	MDR 2.10	-	Engineering sample

Contents

1 Functional description

1.1 Overview

The NEO-M9V-20B GNSS receiver features the u-blox M9 standard precision GNSS platform with 3D multi-mode dead reckoning (MDR). It provides exceptional sensitivity and acquisition times for all L1 GNSS systems. u-blox M9 receivers are available in different variants to serve automotive and industrial tracking applications, such as navigation, telematics and UAVs.

NEO-M9V-20B is the first u-blox GNSS receiver with untethered (UDR) and automotive dead reckoning (ADR), specially designed for fleet management and micromobility applications. It directly succeeds the u-blox M8 product range, namely NEO-M8U and NEO-M8L.

u-blox M9 receivers support concurrent reception of four GNSS. The high number of visible satellites allows the receiver to select the best signals. This maximizes the position accuracy, in particular under challenging conditions such as deep urban canyons.

u-blox M9 receivers detect jamming and spoofing events and report them to the host, which allows the system to react to such events. RF design effort for NEO-M9V-20B is reduced, as a SAW filter and an LNA are integrated. Advanced filtering algorithms mitigate the impact of RF interference and jamming, thus enabling the product to operate as intended.

The receiver also provides higher navigation rate and improved security features compared to previous u-blox GNSS generations.

Access to native, high-rate sensor data also enables host applications to make full use of the receiver's assets, including the wake-on-motion functionality that allows to turn off the host and save power until motion is detected by the IMU.

1.2 Performance

Parameter	Specification	
Receiver type	Multi-constellation GNSS standard precision receiver	
Accuracy of time pulse signal	RMS 99%	30 ns 60 ns
Frequency of time pulse signal		0.25 Hz to 10 MHz (configurable)
Operational limits[1]	Dynamics Altitude Velocity	≤ 4 g 80,000 m 500 m/s
Position error during GNSS loss[2]	3D Gyro + 3D accelerometer + WT 3D Gyro + 3D accelerometer	2 % 10 %
Max navigation update rate (PVT)[3]	Priority navigation mode Non-priority navigation mode Secondary output	50 Hz 5 Hz 5 Hz
Navigation latency	Priority navigation mode	15 ms

1 Assuming Airborne 4 g platform

2 68% error incurred without GNSS as a percentage of distance of traveled 3000 m, applicable to four-wheel road vehicle

3 Rates with SBAS and QZSS enabled for > 98% fix report rate under typical conditions

Parameter	Specification	
Velocity accuracy[4]		0.08 m/s
Dynamic attitude accuracy[4]	Heading	0.3 deg
	Pitch	0.4 deg
	Roll	0.6 deg
Max sensor measurement output rate	Raw	100 Hz
	Calibrated	100 Hz

GNSS		GPS+GLO+GAL+BDS	GPS+GLO	BDS+GLO
Acquisition[5]	Cold start	24 s	25 s	28 s
	Hot start	2 s	2 s	2 s
	Aided start[6]	3 s	2 s	3 s
Sensitivity[7]	Tracking and nav.	-159 dBm	-159 dBm	-159 dBm
	Reacquisition	-158 dBm	-158 dBm	-158 dBm
	Cold start	-147 dBm	-148 dBm	-146 dBm
	Hot start	-159 dBm	-159 dBm	-158 dBm
Position accuracy PVT [8]	Horizontal	1.5 m	1.7 m	2.5 m
	Vertical	3 m	3.5 m	4.5 m

Table 1: NEO-M9V-20B typical performance in multi-constellation GNSS modes

1.3 Supported GNSS constellations

The NEO-M9V-20B is a concurrent GNSS receiver which can receive and track multiple GNSS systems. The NEO-M9V-20B receiver can be configured for concurrent GPS, GLONASS, Galileo and BeiDou plus SBAS and QZSS reception. If power consumption is a key factor, then the receiver can be configured for a subset of GNSS constellations.

Supported GNSS systems and their signals are:

GPS / QZSS	GLONASS	Galileo	BeiDou
L1C/A (1575.42 MHz)	L1OF (1602 MHz + k*562.5 kHz, k = –7,..., 5, 6)	E1-B/C (1575.42 MHz)	B1I (1561.098 MHz)

Table 2: Supported GNSS systems and signals

The following GNSS assistance services can be activated:

AssistNow™ Online	AssistNow™ Offline	AssistNow™ Autonomous
Supported	Not supported	Not supported

Table 3: Supported assisted GNSS (A-GNSS) services

NEO-M9V-20B supports the following augmentation systems:

SBAS	QZSS	IMES	Differential GNSS
EGNOS, GAGAN, MSAS and WAAS supported	L1S supported	Not supported	Not supported

Table 4: Supported augmentation systems

4 68% at 30 m/s for dynamic operation

5 Commanded starts. All satellites at -130 dBm. GPS always in combination with QZSS and SBAS. Measured at room temperature.

6 Dependent on the speed and latency of the aiding data connection, commanded starts.

7 Demonstrated with a good external LNA. Measured at room temperature.

8 CEP, 50%, open sky with SBAS and QZSS enabled, -130 dBm, > 6 SVs

☞ The SBAS and QZSS augmentation systems can be enabled only if GPS operation is also enabled.

1.4 Supported protocols

The NEO-M9V-20B supports the following protocols:

Protocol	Type
UBX	Input/output, binary, u-blox proprietary
NMEA 4.11 (default), 4.10, 4.0, 2.3, and 2.1	Input/output, ASCII

Table 5: Supported protocols

For specification of the protocols, see the interface description [2].

1.5 Firmware features

Feature	Description
Advanced calibration handling	Calibration information can be stored with the host
Assisted GNSS	AssistNow Online supported
Automotive Dead Reckoning	Combines satellite and sensor-based navigation (IMU and odometer input)
Automatic alignment	Automatic estimation of the alignment angles (automotive dynamic model only)
Backup modes	Hardware backup mode, software backup mode
Dual output	GNSS only and Fused (GNSS+DR) output
Geofencing	
Odometer	Measure traveled distance with support for different user profiles
Untethered dead reckoning	Combines satellite and sensor-based navigation (IMU)
Upgradeable firmware	Firmware in flash memory can be upgraded
Wake on motion	Wakes up the receiver and the host while the receiver is in SW backup mode
Weak signal compensation	Improves position and speed accuracy with low signal levels

Table 6: Firmware features

Feature	Description
Anti-jamming	RF interference and jamming detection and reporting
Anti-spoofing	Spoofing detection and reporting
Configuration lockdown	Receiver configuration can be locked by command
Message integrity	All messages signed with SHA-256
Secure boot	Only signed FW images executed

Table 7: Security features

1.6 Multi-mode dead reckoning

u-blox's proprietary multi-mode dead reckoning (MDR) consists of two operating modes: untethered dead reckoning (UDR) and automotive dead reckoning (ADR). UDR is based on sensor fusion dead reckoning (SFDR) technology, which combines multi-constellation GNSS measurements with the NEO-M9V-20B's internal 6-axis IMU only. Whereas ADR is based on SFDR technology, which combines multi-constellation GNSS measurements with the NEO-M9V-20B's internal 6-axis IMU and wheel tick or speed.

The module has ready-to-use UDR and could perform advanced ADR when speed pulses from the vehicle's wheel tick (WT) sensor are provided. Alternatively, the vehicle speed data can be provided as messages via a serial interface.

Sensor data and GNSS signals are processed together, achieving 100% coverage, with highly accurate and continuous positioning even in GNSS-hostile environments (for example, urban canyons) or in case of GNSS signal absence (for example, tunnels and parking garages).

☞ For more details, see the Integration manual [1].

The NEO-M9V-20B combines GNSS and dead reckoning measurements and computes a position solution at rates of up to 50 Hz in the priority navigation mode.

⚠ The NEO-M9V-20B will work optimally in priority navigation mode when the IMU and WT sensors are calibrated, and the alignment angles are configured correctly.

Dead reckoning allows navigation to commence as soon as power is applied to the module (that is, before a GNSS fix has been established) under the following conditions:

- The vehicle has not been moved while the module has been switched off.
- At least a dead reckoning fix was available when the vehicle was last used.
- A backup supply has been available for the module since the vehicle was last used.

☞ The save-on-shutdown feature can be used when no backup supply is available. All information necessary will be saved to the flash and read from the flash upon restart.

☞ The advanced calibration handling feature can be used when no backup supply is available or the save-on-shutdown feature cannot be used. This feature allows the host to poll and later send the sensor initialization and calibration parameters.

2 System description

2.1 Block diagram

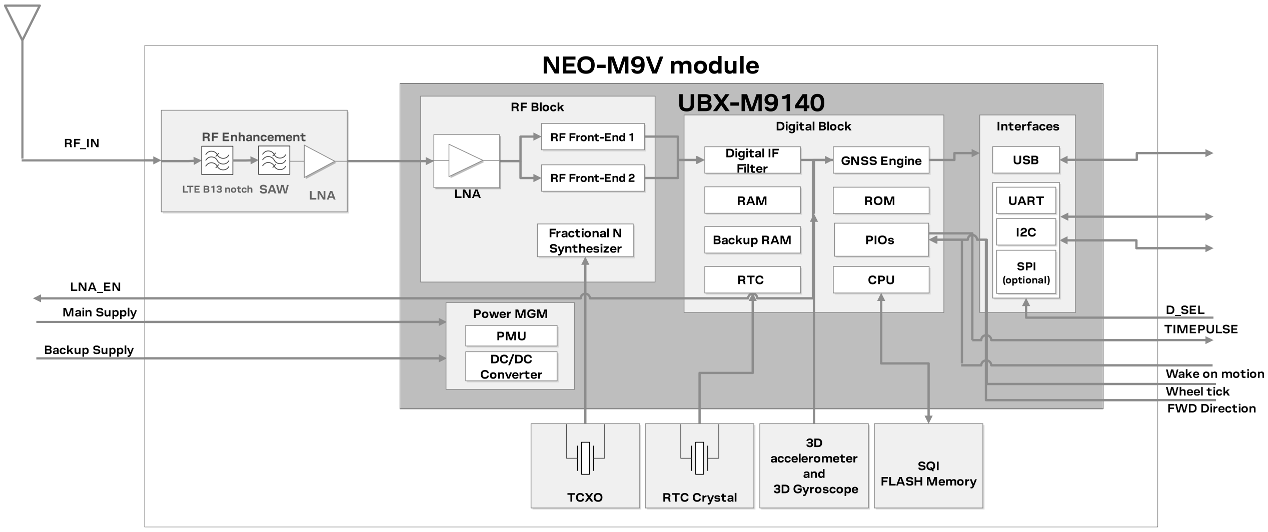


Figure 1: NEO-M9V-20B block diagram

3 Pin definition

3.1 Pin assignment

The pin assignment of the NEO-M9V-20B module is shown in Figure 2. The defined configuration of the PIOs is listed in Table 8.

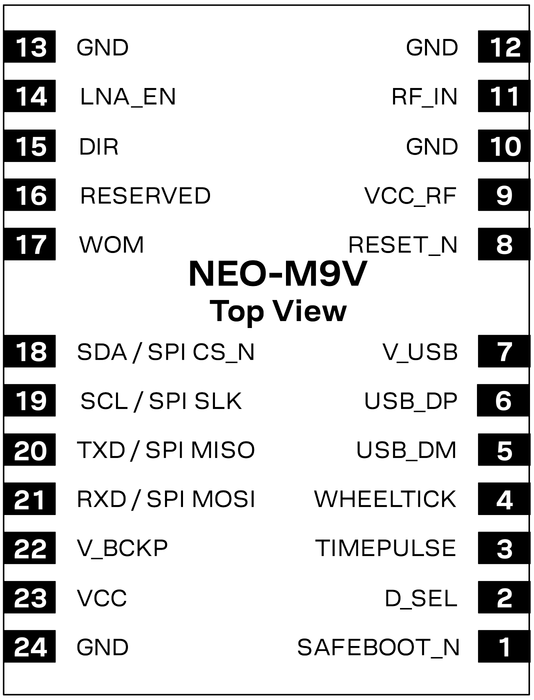


Figure 2: NEO-M9V-20B pin assignment

Pin no.	Name	I/O	Description
1	SAFEBOOT_N	I	SAFEBOOT_N (used for FW updates and reconfiguration, leave open)
2	D_SEL	I	Interface select (open or VCC = UART + I2C; GND = SPI)
3	TIMEPULSE	O	TIMEPULSE (1 PPS, TP2)
4	WHEELTICK	I	Wheel-tick input
5	USB_DM	I/O	USB data (DM)
6	USB_DP	I/O	USB data (DP)
7	V_USB	I	USB supply
8	RESET_N	I	RESET (active low)
9	VCC_RF	O	Voltage for external LNA
10	GND	I	Ground
11	RF_IN	I	GNSS signal input
12	GND	I	Ground
13	GND	I	Ground
14	LNA_EN	O	Antenna/LNA control
15	DIR	I	Direction input for speed pulse
16	Reserved	-	Reserved
17	WOM	O	Wake on motion interrupt

Pin no.	Name	I/O	Description
18	SDA / SPI CS_N	I/O	I2C data if D_SEL = VCC (or open); SPI chip select if D_SEL = GND
19	SCL / SPI SLK	I/O	I2C clock if D_SEL = VCC (or open); SPI clock if D_SEL = GND
20	TXD / SPI MISO	O	UART output if D_SEL = VCC (or open); SPI MISO if D_SEL = GND
21	RXD / SPI MOSI	I	UART input if D_SEL = VCC (or open); SPI MOSI if D_SEL = GND
22	V_BCKP	I	Backup voltage supply
23	VCC	I	Supply voltage
24	GND	I	Ground

Table 8: NEO-M9V-20B pin assignment

☞ For detailed information on the pin functions and characteristics see the integration manual [1].

4 Electrical specification

The limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only. Operation of the device at these or at any other conditions above those given below is not implied. Exposure to limiting values for extended periods may affect device reliability.

Where application information is given, it is advisory only and does not form part of the specification.

For detailed information on the device integration, see the integration manual [1].

4.1 Absolute maximum ratings

Parameter	Symbol	Condition	Min	Max	Units
Power supply voltage	VCC		-0.5	3.6	V
Voltage ramp on VCC[9]			20	8000	µs/V
Backup battery voltage	V_BCKP		-0.5	3.6	V
Voltage ramp on V_BCKP[9]			20		µs/V
Input pin voltage	Vin	VCC ≤ 3.1 V	-0.5	VCC + 0.5	V
		VCC > 3.1 V	-0.5	3.6	V
VCC_RF output current	ICC_RF			100	mA
Supply voltage USB	V_USB		–0.5	3.6	V
USB signals	USB_DM, USB_DP		-0.5	V_USB + 0.5	V
Input power at RF_IN	Prfin	source impedance = 50 Ω, continuous wave		13[10]	dBm
Storage temperature	Tstg		-40	+85	°C

Table 9: Absolute maximum ratings

The product is not protected against overvoltage or reversed voltages. Voltage spikes exceeding the power supply voltage specification, given in the table above, must be limited to values within the specified boundaries by using appropriate protection diodes.

4.2 Operating conditions

All specifications are at an ambient temperature of 25 °C. Extreme operating temperatures can significantly impact the specification values. Applications operating near the temperature limits should be tested to ensure the specification.

Parameter	Symbol	Min	Typical	Max	Units	Condition
Power supply voltage	VCC	2.7	3.0	3.6	V	
Backup battery voltage	V_BCKP	1.65		3.6	V	
Backup battery current	I_BCKP		36		µA	V_BCKP = 3 V, VCC = 0 V
SW backup current	I_SWBCKP		0.5		mA	
Input pin voltage range	Vin	0		VCC	V	
Digital IO pin low level input voltage	Vil			0.4	V	

9 Exceeding the ramp speed may permanently damage the device

10 +13 dBm for outband; 0 dBm for inband

Parameter	Symbol	Min	Typical	Max	Units	Condition
Digital IO pin high level input voltage	Vih	0.8 * VCC			V	
Digital IO pin low level output voltage	Vol			0.4	V	Iol = 2 mA
Digital IO pin high level output voltage	Voh	VCC – 0.4			V	Ioh = 2 mA
VCC_RF voltage	VCC_RF		VCC - 0.1		V	
VCC_RF output current	ICC_RF			50	mA	
Receiver chain noise figure[11]	NFtot		TBD		dB	
External gain (at RF_IN)	Ext_gain			30	dB	
Operating temperature	Topr	-40	+25	85	°C	

Table 10: Operating conditions

☞ Operation beyond the specified operating conditions can affect device reliability.

4.3 Indicative power requirements

Table 11 lists examples of the total system supply current including RF and baseband section for a possible application.

☞ Values in Table 11 are provided for customer information only, as an example of typical current requirements. The values are characterized on samples by using a cold start command. Actual power requirements can vary depending on FW version used, external circuitry, number of satellites tracked, signal strength, type and time of start, duration, and conditions of test.

Symbol	Parameter	Conditions	GPS+GLO+GAL+BDS	GPS+GLO	BDS+GLO	Unit
I_{PEAK}	Peak current	Acquisition	67	63	64	mA
I_{VCC}[12]	VCC current	Acquisition	53	43	47	mA
		Tracking	49	43	44	mA

Table 11: Currents to calculate the indicative power requirements

All values in Table 11 are measured at 25 °C ambient temperature. SBAS and QZSS are activated in all measurements.

11 Only valid for the GPS

12 Simulated signal, current measured at 3.0 V

5 Communications interfaces

There are several communications interfaces including UART, SPI, I2C[13] and USB.

All the inputs have internal pull-up resistors in normal operation and can be left open if not used. All the PIOs are supplied by VCC, therefore all the voltage levels of the PIO pins are related to VCC supply voltage.

5.1 UART

The NEO-M9V-20B has one UART interface which supports configurable baud rates. See the integration manual [1].

Hardware flow control is not supported.

The UART1 is enabled if D_SEL pin of the module is left open or "high".

Symbol	Parameter	Min	Max	Unit
R_u	Baud rate	4800	921600	bit/s
Δ_{Tx}	Tx baud rate accuracy	-1%	+1%	-
Δ_{Rx}	Rx baud rate tolerance	-2.5%	+2.5%	-

Table 12: NEO-M9V-20B UART specifications

5.2 SPI

The NEO-M9V-20B has an SPI slave interface that can be selected by setting D_SEL = 0. The SPI pins available are:

- SPI_MISO (TXD)
- SPI_MOSI (RXD)
- SPI_CS_N
- SPI_CLK

The SPI interface is designed to allow communication to a host CPU. The interface can be operated in slave mode only. Note that SPI is not available in the default configuration because its pins are shared with the UART and I2C interfaces. The maximum transfer rate using SPI is 125 kB/s and the maximum SPI clock frequency is 5.5 MHz.

This section provides SPI timing values for the NEO-M9V-20B slave operation. The following tables present timing values under different capacitive loading conditions. Default SPI configuration is CPOL = 0 and CPHA = 0.

13 I2C is a registered trademark of Philips/NXP

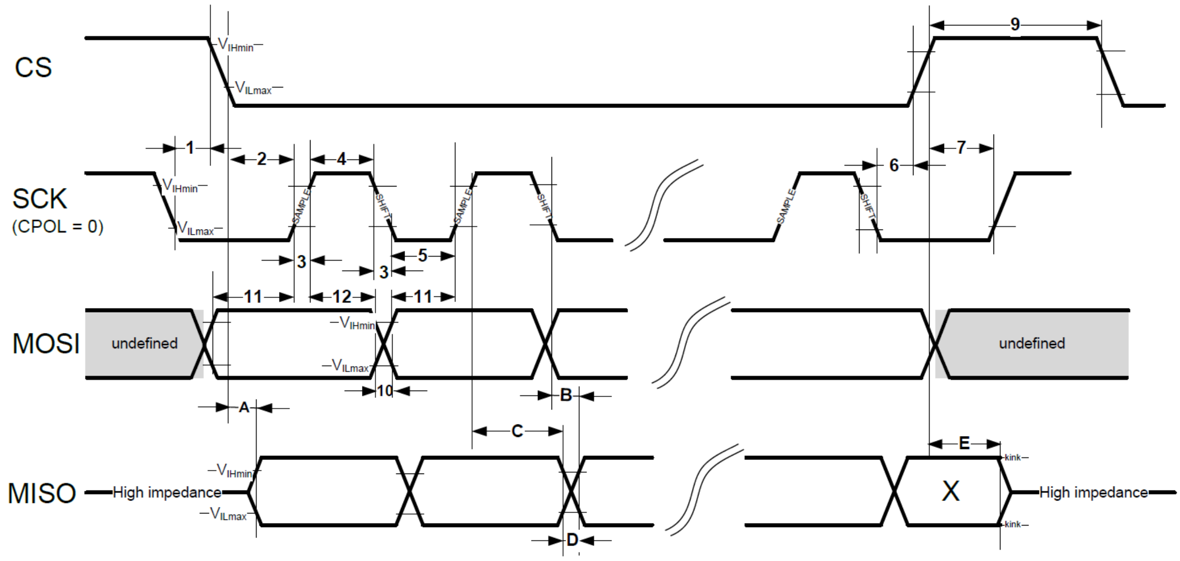


Figure 3: NEO-M9V-20B SPI specification mode 1: CPHA=0 SCK = 5.33 MHz

☞ Timings 1 - 12 are not specified here as they are dependent on the SPI master. Timings A - E are specified for SPI slave.

Timing value at 2 pF load	Min (ns)	Max (ns)
"A" - MISO data valid time (CS)	14	38
"B" - MISO data valid time (SCK) weak driver mode	21	38
"C" - MISO data hold time	114	130
"D" - MISO rise/fall time, weak driver mode	1	4
"E" - MISO data disable lag time	20	32

Table 13: NEO-M9V-20B SPI timings at 2 pF load

Timing value at 20 pF load	Min (ns)	Max (ns)
"A" - MISO data valid time (CS)	19	52
"B" - MISO data valid time (SCK) weak driver mode	25	51
"C" - MISO data hold time	117	137
"D" - MISO rise/fall time, weak driver mode	6	16
"E" - MISO data disable lag time	20	32

Table 14: NEO-M9V-20B SPI timings at 20 pF load

Timing value at 60 pF load	Min (ns)	Max (ns)
"A" - MISO data valid time (CS)	29	79
"B" - MISO data valid time (SCK) weak driver mode	35	78
"C" - MISO data hold time	122	152
"D" - MISO rise/fall time, weak driver mode	15	41
"E" - MISO data disable lag time	20	32

Table 15: NEO-M9V-20B SPI timings at 60 pF load

5.3 I2C

An I2C-compliant interface is available for communication with an external host CPU. The interface can be operated in slave mode only. It is compatible with the I2C industry standard fast mode. Since the maximum SCL clock frequency is 400 kHz, the maximum bit rate is 400 kbit/s. The interface stretches the clock when slowed down while serving interrupts, therefore the real bit rates may be slightly lower. The maximum clock stretching time that the host can expect is 20 ms.

☞ The I2C interface is only available with the UART default mode. If the SPI interface is selected by using D_SEL = 0, the I2C interface is not available.

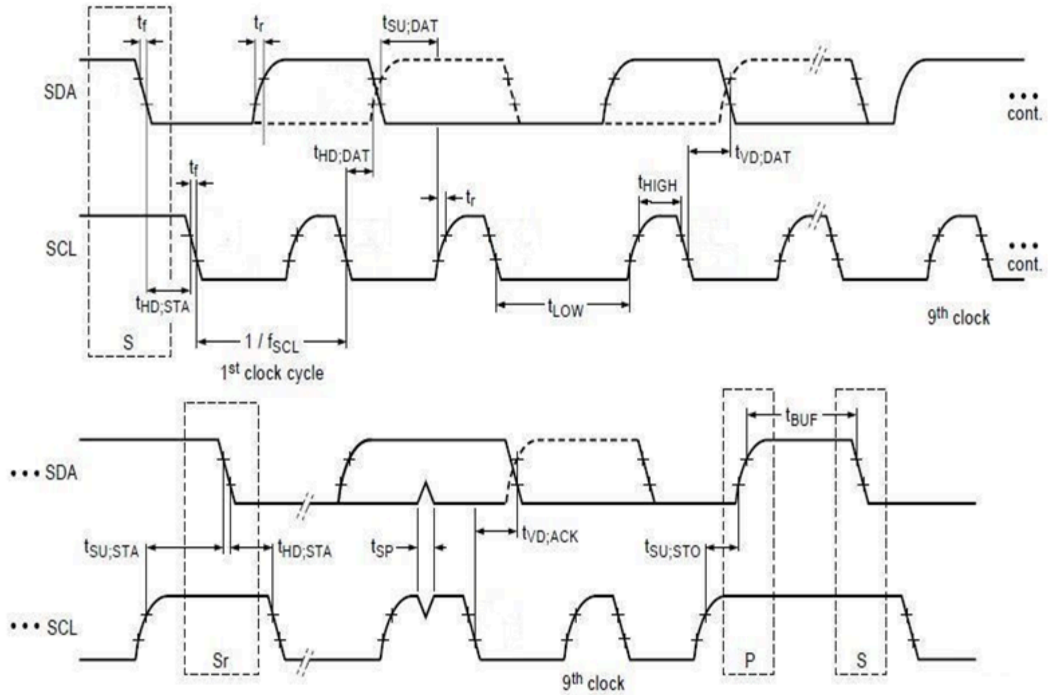


Figure 4: NEO-M9V-20B I2C slave specification

Symbol	Parameter	Min (Standard / Fast mode)	Max	Unit
f_{SCL}	SCL clock frequency	0	400	kHz
$t_{HD;STA}$	Hold time (repeated) START condition	4.0/1	-	µs
t_{LOW}	Low period of the SCL clock	5/2	-	µs
t_{HIGH}	High period of the SCL clock	4.0/1	-	µs
$t_{SU;STA}$	Set-up time for a repeated START condition	5/1	-	µs
$t_{HD;DAT}$	Data hold time	0/0	-	µs
$t_{SU;DAT}$	Data set-up time	250/100		ns
t_r	Rise time of both SDA and SCL signals	-	1000/300 (for C = 400pF)	ns
t_f	Fall time of both SDA and SCL signals	-	300/300 (for C = 400pF)	ns
$t_{SU;STO}$	Set-up time for STOP condition	4.0/1	-	µs
t_{BUF}	Bus-free time between a STOP and START condition	5/2	-	µs
$t_{VD;DAT}$	Data valid time	-	4/1	µs
$t_{VD;ACK}$	Data valid acknowledge time	-	4/1	µs
V_{nL}	Noise margin at the low level	0.1 VCC	-	V
V_{nH}	Noise margin at the high level	0.2 VCC	-	V

Table 16: NEO-M9V-20B I2C slave timings and specifications

5.4 USB

The USB 2.0 FS (Full speed, 12 Mbit/s) interface can be used for host communication. Due to the hardware implementation, it may not be possible to certify the USB interface. The V_USB pin supplies the USB interface.

5.5 WT (wheel tick) and DIR (forward/reverse indication)

NEO-M9V-20B pin 4 (WT) is available as a wheel-tick input. The pin 15 (DIR) is available as a direction input (forward/reverse indication).

By default the wheel tick count is derived from the rising edges of the WT input.

For optimal performance the wheel tick resolution should be less than 5 cm.

The DIR input shall indicate whether the vehicle is moving forwards or backwards.

Alternatively, the vehicle WT (or speed) and DIR inputs can be provided via one of the communication interfaces with UBX-ESF-MEAS messages.

☞ For more details, see the integration manual [1].

5.6 Default interface settings

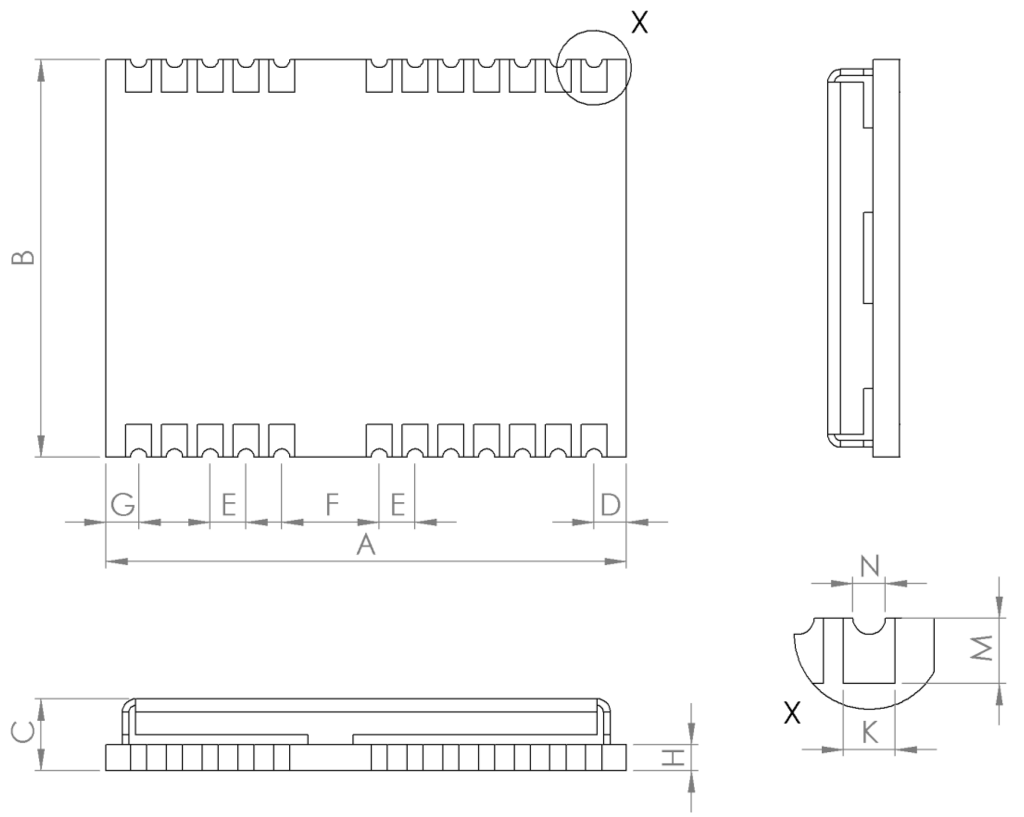
Interface	Settings
UART	38400 baud, 8 bits, no parity bit, 1 stop bit. Output messages: NMEA **GGA, GLL, GSA, GSV, RMC, VTG, TXT** (no UBX). Input protocols: UBX and NMEA.
USB	Output messages activated as in UART. Input protocols available as in UART.
I2C	Output messages activated as in UART. Input protocols available as in UART.
SPI	Output messages activated as in UART. Input protocols available as in UART.

Table 17: Default interface settings

☞ Refer to the applicable interface description [2] for information about further settings.

By default the NEO-M9V-20B outputs NMEA messages that include satellite data for all GNSS bands being received. This results in a higher-than-before NMEA load output for each navigation period. Make sure the UART baud rate being used is sufficient for the selected navigation rate and the number of GNSS signals being received.

6 Mechanical specification



Symbol	Min. (mm)	Typ. (mm)	Max. (mm)
A	15.9	16.0	16.6
B	12.1	12.2	12.3
C	2.2	2.4	2.6
D	0.9	1.0	1.3
E	1.0	1.1	1.2
F	2.9	3.0	3.1
G	0.9	1.0	1.3
H		0.82	
K	0.7	0.8	0.9
M	0.8	0.9	1.0
N	0.4	0.5	0.6
Weight		1.6g	

Figure 5: NEO-M9V-20B mechanical drawing

7 Reliability tests and approvals

NEO-M9V-20B modules are based on AEC-Q100 qualified GNSS chips.

Tests for product family qualifications are according to AEC-Q104 "Failure Mechanism Based Stress Test Qualification For Multichip Modules (MCM) In Automotive Applications", and appropriate standards.

7.1 Approvals

The NEO-M9V-20B is designed to in compliance with the essential requirements and other relevant provisions of Radio Equipment Directive (RED) 2014/53/EU.

The NEO-M9V-20B complies with the Directive 2011/65/EU (EU RoHS 2) and its amendment Directive (EU) 2015/863 (EU RoHS 3).

Declaration of Conformity (DoC) is available on the u-blox website.

8 Labeling and ordering information

This section provides information about product labeling and ordering. For information about moisture sensitivity level (MSL), product handling and soldering see the integration manual [1].

8.1 Product labeling

The labeling of the NEO-M9V-20B modules provides product information and revision information. For more information contact u-blox sales.

8.2 Explanation of product codes

Three product code formats are used. The **Product name** is used in documentation such as this data sheet and identifies all u-blox products, independent of packaging and quality grade. The **Ordering code** includes options and quality, while the **Type number** includes the hardware and firmware versions.

Table 18 below details these three formats.

Format	Structure	Product code
Product name	PPP-TGV	NEO-M9V
Ordering code	PPP-TGV-NNQ	NEO-M9V-20B
Type number	PPP-TGV-NNQ-XX	NEO-M9V-20B-00

Table 18: Product code formats

The parts of the product code are explained in Table 19.

Code	Meaning	Example
PPP	Product family	NEO
TG	Platform	M9 = u-blox M9
V	Variant	V = MDR Multi-mode Dead Reckoning
NNQ	Option / Quality grade	NN: Option [00...99] Q: Grade, A = Automotive, B = Professional
XX	Product detail	Describes hardware and firmware versions

Table 19: Part identification code

8.3 Ordering codes

Ordering code	Product	Remark
NEO-M9V-20B	u-blox NEO-M9V module, Professional grade	

Table 20: Product ordering codes

☞ Product changes affecting form, fit or function are documented by u-blox. For a list of Product Change Notifications (PCNs) see our website at: https://www.u-blox.com/en/product-resources.

Related documents

[1] NEO-M9V Integration manual, UBX-21029776

[2] MDR 2.10 Interface description, UBX-21036678

[3] Packaging information for u-blox chips, modules, and antennas, UBX-14001652

☞ For regular updates to u-blox documentation and to receive product change notifications please register on our homepage https://www.u-blox.com.

Revision history

Revision	Date	Name	Status / comments
R01	05-Jan-2022	apai/ssid	Advance information

Contact

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